Final Report

Title: UV Spectroscopy of Low-Redshift Active Galaxies, Year 1

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Statement of Work:

Ultraviolet spectra of bright Seyfert 1 galaxies will be obtained with the Hubble Space Telescope. Near-simultaneous IUE spectra will be used to establish the continuum level, and near-simultaneous optical spectra will be obtained to study the important lines in that region. The observations will be used to pursue the following scientific goals:
1) The broad and narrow components of the strong emission lines will be deconvolved.Separate fluxes from the broad- and narrow-line regions will be determined for comparison with photoionization models.
2) The broad-line profiles will be extracted for comparison with kinematic models, and line ratios will be determined as a function of radial velocity to study the manner in which the physical conditions (e.g., ionization parameter) change across the broad-line region.
3) Many of the weak UV emission lines and emission lines from optical spectra will be compared to estimate the reddening along the line of sight and to provide further clues to the chemical composition, density, and ionizing spectrum in the emission-line regions.
4) Absorption lines from the Galactic halo, the intergalactic medium, and the Seyfert galaxy will be used to establish the physical conditions and chemical composition of the gas. Any absorption lines that originate in or near the broad-line region would provide valuable information on cloud motions and the covering factor.
5) The strong Fe II emission in the UV will be used to determine accurate Fe II/L-alpha ratios for comparison with photoionization models, which currently underestimate this ratio, and to determine if very high density clouds are responsible for most of the Fe II emission.

In addition to the above scientific studies, other tasks relating to the GTO 1170 program will be performed. The proposal will be updated upon request of the GHRS team leader to include changes in the scientific justification, modification of targets lists and exposure times to meet new time allocations, and modifications to instrument parameters to allow for changes in HST operational capabilities. In addition, GHRS team meetings and HST workshops relevant to the program will be attended.

Results:

Ultraviolet spectra of two Seyfert 1 galaxies were obtained with the Faint Object Spectrograph (FOS) on the Hubble Space Telescope (HST). Mrk 509 was observed with HST on June 20 - 21, 1992 and NGC 5548 was observed with HST on July 4 - 5, 1992. The FOS spectra cover the range 1200 - 3300 angstroms at a resolution of R = 1000 and an estimated signal-to-noise ratio of SNR = 40 in the continuum. IUE spectra were obtained within a day of the HST/FOS observations to determine the absolute calibration level of the UV spectra. Optical spectra at similar resolution and signal-to-noise were obtained over the wavelength region 3200 - 8000 angstroms by collaborators at Palomar, Lick, and Lowell Observatories.

The IUE spectra were re-extracted from the line-by-line files using a Gaussian extraction routine to improve the signal-to-noise ratio; the absolute fluxes of the Gaussian-extracted and standard IUESIPS spectra agree to within a few percent across the usable wavelength range. The individual HST/FOS observations for each grating were coadded, and the average spectra were resampled so that the wavelength bin size was equal to one-half of a resolution element. The average spectra for the G130H, G190H, and G270H gratings were merged, and the continuum level was determined using polynomial fits to spectral regions free of emission or absorption lines.

For NGC 5548, the strong emission lines of Lyman-alpha, CIV, C III] and Mg II were deconvolved into separate broad and narrow components using an IDL routine originally developed for use with optical and IUE spectra of active galaxies. The broad emission lines and UV continuum are at unusually low flux levels (compared to those seen in the past 14 years of IUE observations).

A paper entitled ''FOS Spectra of the UV Emission Lines in NGC 5548: Detection of Strong Narrow Components'', was prepared for submission to the Astrophysical Journal (Letters). A comparison of the narrow lines of Lyman-alpha, C IV, C III], He II, and Mg II with those found in IUE studies of Seyfert 2 galaxies indicates that the physical conditions are noticeably different in the narrow-line region (NLR) of this Seyfert 1 galaxy. The C IV line is very strong, relative to the other lines, which indicates a higher ionization parameter. In addition, the Mg II line is weak or absent, indicating that the NLR clouds are fully ionized and therefore lack the transition region from which the majority of this line arises. Thus, it appears likely that the NLR clouds in NGC 5548 experience a much higher level of ionizing flux than those in typical Seyfert 2 galaxies. Future HST/FOS observations will be used to determine if this result extends to other Seyfert 1 galaxies, indicating a genuine difference between the two types of Seyfert galaxy.

Publications:

''FOS Spectroscopy of the Seyfert 1 Galaxy NGC 5548'', Crenshaw, D.M., Boggess, A., and Wu, C.-C. 1993, BAAS, in press.

''FOS Spectra of the UV Emission Lines in NGC 5548: Detection of Strong Narrow Components'', Crenshaw, D.M., Boggess, A., and Wu, C.-C. 1993, ApJ, submitted.